DEPARTMENT OF PUBLIC SERVICE REGULATION
BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MONTANA

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IN THE MATTER of the Complaint of The MONTANA STATE AFL-CIO And The MONTANA STATE BUILDING AND CONSTR-UCTION TRADES COUNCIL And The INVESTIGATION BY THE MONTANA PUBLIC SERVICE COMMISSION Into The Alleged Safety Defects In The Montana Power Company's New 16-Inch Natural Gas Transmission Line.	))))))))	UTILITY DIVISION DOCKET NOS. 83.11.82 and 84.1.3 ORDER NO. 5057b

FINAL ORDER

APPEARANCES

FOR THE MONTANA STATE AFL-CIO AND THE MONTANA STATE BUILDING AND CONSTRUCTION TRADES COUNCIL:

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FOR THE MONTANA POWER COMPANY:

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FOR THE MONTANA CONSUMER COUNSEL:

John C. Allen, Staff Attorney, 34 West Sixth Avenue, Helena, Montana 59620

FOR THE COMMISSION:

Eileen E. Shore, Dennis Crawford, James Watson, Montana Public Service Commission, 2701 Prospect Avenue, Helena, Montana 59620

BEFORE:

CLYDE JARVIS, Chairman
HOWARD L. ELLIS, Vice Chairman
JOHN B. DRISCOLL, Commissioner
TOM MONAHAN, Commissioner
DANNY OBERG, Commissioner

FINDINGS OF FACT

I. BACKGROUND

1. Subsequent to the Commission issuing Order No. 5057a on June 12, 1984, Montana Power Company (MPC) submitted its "Plan to Demonstrate Integrity of Installed Portion of New 16 Inch Pipeline." The following is the Plan Outline:

1) A well-qualified engineering consultant will be retained to advise MPC on technical aspects of the Plan.

2) A qualified management expert will review MPC's analysis of its project organization to date, as well as a reorganized project supervision plan. An independent review will thus be obtained of project organization before construction proceeds on the north portion of the project.

3) A nationally-recognized testing organization will be retained to conduct a radiographic audit on the girth welds made on the 104 miles of pipeline.

4) Surveys:

A. Information - recording pigging surveys will be run to locate geometric deformation of pipe both before and after hydrotesting.

B. A Pearson-type holiday detection survey will be conducted to determine the condition of the pipe coating.

5) Hydrostatic test will be conducted of the remaining 62 miles of pipeline to the standards applied to the 42 miles of previously tested pipe.

6) The line will be exposed and examined during repair work associated with the foregoing steps. PSC staff will be informed of all exposures, excavations and repairs

to facilitate their observation of the condition of the installed line and any corrective measures taken, if such observation is feasible. Reports on all excavations and repairs will be furnished to the PSC.

On June 13, 1984 a "Revised Plan" was submitted outlining additional, details of carrying out Plan.

2. Williams Brothers Engineering Company, of Tulsa, Oklahoma, advised MPC on the technical aspects of the Plan and performed a review and evaluation of MPC's management practices for the pipeline.

3. Southwest Research Institute, of San Antonio, Texas, performed a review of the available radiographs and made a Fitness-For-Service determination.

4. A "Kaliper Pigging Survey" was conducted by T.D.W. Pipeline Surveys of Tulsa, Oklahoma and the first run was on June 9, 1984.

5. Hydrostatic testing was performed by Brister, Inc., of Amarillo Texas.

6. Radiography for the remedial work was contracted to Mid-Con Inspection Services, Inc. of Casper, Wyoming.

7. Remedial work, as of November 8, 1984, was performed at 69 excavations. Excavation were made at all points indicated by the Kaliper Pig as being out of compliance with Part 192 of the pipeline safety regulations. Excavations were also made to correct damage caused by vandalism such as drill holes and bullet holes. Other excavations were made where the radiographic audit indicated that girth welds were not in compliance with A.P.I. 1104 standards.

8. Montana Power Company filed excavation reports for each excavation, describing the conditions found and corrective action taken.

9. Williams Brothers Engineering Company filed progress reports as the Plan was implemented.

Williams Brothers Engineering Company filed a "Review and Evaluation of Montana Power Company's Management Structures For The 16-Inch Pipeline From Morel Junction to Cut Bank, Montana."

10. Southwest Research Institute filed a "Fitness-For-Service Determination of the Warm Springs to Augusta, Montana, Gas Pipeline of the Montana Power Company."

11. In addition, other experts were hired by Montana Power Company and the parties involved, to review the results of all testing and reporting. Additional consultants have been involved in this investigation.

12. The Montana Public Service Commission retained the services of Dr. Bruce W. Christ, Fracture & Deformation Division, Center for Materials Science, National Bureau of Standards, Boulder, Colorado 80303.

13. The Montana State AFL-CIO and the Montana State Building & Construction Trades Council retained Brian L. Jones, Consulting Metallurgist 1209 Lamson Circle, Pittsburgh, Pennsylvania 15241.

14. Montana Power Company hired Eugene A. Lange, P.E., 5101 River Road, Bethesda, Maryland 10816.

15. On August 7, 1985, Montana Power Company filed a Request for Waiver. The petition is for a waiver of certain regulations concerning its new 16-inch pipeline. More specifically, MPC seeks waiver of 49 C.F.R. 192.241(c) and 192.245(a) concerning certain pipeline girth welds, of 192.303 regarding compliance with contract specifications and of 192.243(f) concerning nondestructive testing records. In addition, MPC requests waiver of 8.4 and 8.9 of API Standard 1104 (1980 ed.) as respects penetrameters and film density. The Request for Waiver further states, "If MPC is required to bring all girth welds for which a waiver is sought into literal compliance with the Code, it will result in an unnecessary expenditure of time and resources. In fact, any such undertaking could be counter-productive in terms of safety, given the difficulty of the tasks involved, the possibility of damage to the pipe and the difficulty of inspection. Furthermore, the environmental disruption which would ensue cannot be overlooked."

16. On August 29, 1985, the Commission issued a Notice of Waiver Request and Intent to Enter Order and Opportunity for Public Hearing. Requests for hearing were to be filed by September 25, 1985. No requests for hearing were received.

17. On August 30, 1985, an Order Convening Informal Technical Conference was issued for an informal technical conference to be held on September 17, 1985, at the Commission's conference room, 2701 Prospect Avenue, Helena, Montana.

18. The informal technical conference was held with the five Commissioners present, Staff Attorney Eileen Shore, Staff member's Dennis Crawford, James Watson, and Consultant Dr. Bruce W. Christ; Montana Power Company was represented by its attorneys Bob Gannon and Brian Corcoran as well as Eugene A. Lange, P.E., Sam Wenk of Southwest Research Institute, and Clint McClure of Williams Brothers Engineering Company. The AFL-CIO was represented by its attorneys William A. Rossbach and Karl F. Englund and Consulting Metallurgist, Brian L. Jones.

19. MPC presented their waiver request and documents in support of that waiver request. Discussion centered around the reports, test results, waiver and the remedial work that has been accomplished to date and about the additional remedial work that must be done before the line is ready for service.

20. Following the informal technical conference, it was agreed that Jones' "Review of SWRI Document" be made part of the record upon which the PSC would make its decision on the waiver request.

21. As a result of the technical conference, MPC submitted additional data at the request of Christ and Jones. Following receipt of the information, Jones submitted to the PSC an informal analysis of that information. In addition, attorneys Englund and Rossbach submitted a letter to Chairman Jarvis on October 8, 1985. In that letter the AFL-CIO and the Montana Building and Construction Trades Council informed the PSC that it would take no position on MPC's waiver request, and that a contested case proceeding would not be requested. The letter concluded with the statement, "you have been provided with the information upon which you can make this difficult decision, and we trust your judgment."

22. The Englund-Rossbach letter accurately summarized Jones' analysis of the MPC remedial program and waiver request:

> The Montana Power Company's fracture mechanics analysis was reviewed by our expert, Dr. Brian L. Jones of Pittsburgh Pennsylvania. The Power Company's analysis had concluded that following the removal of just three welds containing cracks longer then three inches, the pipeline would be fit for its intended use. Based upon his extensive experience with the actual application of fracture mechanics theories to pipelines, Dr. Jones recommended the use of more conservative assumptions. Using Dr. Jones' assumptions, all

> welds containing cracks longer than one inch must be repaired. The Power Company has agreed with Dr. Jones' request.

23. The basic issue presented by the waiver request is whether a fracture mechanics approach gives the PSC and the people of Montana a solid assurance that the pipeline already in the ground will be safe and reliable, even though it does not comply with the workmanship standards of API 1104. Jones' summarized API 1104 in these words:

> API 1104 defect tolerance levels have no basis in fracture mechanics. For the most part they are very conservative in regard to their significance to the structural integrity of the line. They represent a workmanship standard which it is reasonable to expect a pipeline welder to achieve under the usual conditions which pertain during construction above the ditch.

In applying this general analysis to the MPC pipeline, however, Jones stated:

> For an occasion such as the MPC pipeline, where defects outside API 1104 tolerance levels are discovered after construction and after burial, the situation is very different. Here adherence to the workmanship standard can give rise to unnecessary delay and expense. Repeated repair and the difficulty of in-the-ditch inspection can in fact be counter productive in safety terms. The use of engineering critical assessments of defects in such situations is therefore fully supported.

24. As later sections of this order demonstrate, the subjects under consideration in this waiver request are extremely technical. Despite their esoteric nature, however, the question of safety and reliability must remain the central focus of our concern. As stated in the Englund-Rossbach letter, "You have uncontested engineering testimony that the defective welds are, according to fracture mechanics theories, fit for their intended purpose. Only you can decide whether that testimony supports a departure from a standard of workmanship which our members could have achieved."

25. As will be discussed, it is the PSC's conclusion that expert testimony supports grant of the waivers requested, so long as appropriately stringent monitoring procedures are adopted by MPC. The grant does not of course, constitute any kind of approval of the way in which MPC set out to construct this pipeline. The PSC believes that no fair-minded person could disagree with the description in Order No. 5057a regarding MPC's initial approach.

26. By contrast, since that order, MPC has done an exemplary job in its attempts to put its pipeline house in order. Repair work has been overseen by highly competent individuals. In addition, as noted in the Englund-Rossbach letter, "Throughout this process the Power Company, and in particular, its Chief Counsel Bob Gannon, kept us well informed of its activities and the progress of its remedial program." Thus, we have a company at both its best and its worst in this docket. Needless to say, the PSC fully expects MPC's best efforts in the construction of the second half of the line. Given the experience gained by all in the long and difficult process to date, the second half of this line should be an example of the very best industry practices.

27. Based on the highly competent and objective advice of its consultant Bruce Christ as well as the invaluable information provided by the AFL-CIO and the Montana Building and Construction Trades Council throughout this long and complicated docket, the PSC finds, for reasons set out in the balance of this order, that grant of the waiver will serve the public interest while not threatening public safety.

II. RESULTS OF THE GIRTH WELD AUDIT

28. The purpose of a girth weld audit is to examine inspection records which were accepted at the time of construction in order to determine the kind and length of girth weld discontinuities which would be identified as defects. Welding standard API 1104/Section G, which is incorporated into the Federal Pipeline Regulations (CFR 49, Part 192) by reference, is the source of definitions of girth weld defects.

29. An audit of 100 percent of the available girth weld radiographs (approximately 11,033) from the MPC pipeline was carried out by Southwest Research Institute in 1984. A review of identified "crack-like" indications was conducted early in 1985. A summary of the number of identified defects by type appears in Table 1. A summary of the number of girth welds containing identified defects appears in Table 2.

30. The number of missing, incomplete, unreadable or otherwise defective girth weld radiographs was estimated to be 1246. Of these, 885 were missing. On September 25, 1985, MPC submitted to the PSC a map showing the distribution of missing radiographs along the length (about 104 miles) of the constructed pipeline. (See Appendix B.)

III. RESULTS OF FRACTURE MECHANICS ANALYSIS TO DETERMINE FITNESS FOR SERVICE

A. Fracture Mechanics Methodology

31. The fracture mechanics methology developed in the fitness for analysis of the Trans-Alaska Oil Pipeline System[1] is followed in evaluating the present request for waiver. This methodology evaluates the stability of girth weld defect in the presence of a static applied longitudinal tensile stress. At the time of the Alaska Oil Pipeline rulemaking[2], it was noted that, "Fracture mechanics analysis is acceptable as a basis for granting exemptions from existing standards in appropriate circumstances, if such analysis produces a convincing and conservative estimate of structural integrity." That same rulemaking noted the need for such analysis to be based on adequate technical information. In this case, adequate technical information has been provided in the request for waiver, allowing an evaluation of the MPC pipeline's fitness for service according to the fracture mechanics methodology developed for the Alaska Oil Pipeline.

32. One important aspect of the fracture mechanics methodology is the estimation of the worst-case static longitudinal tensile loading on the buried, internally pressurized pipeline. Factors which contribute to the worst-case loading are listed in Table 3.

33. Another aspect of the fracture mechanics methodology is estimation of the worst case dynamic longitudinal loading on the pipeline during long-term service. Factors which contribute to this are listed in Table 4.

34. The fracture mechanics mathematical models for calculating stable girth weld defect size require information about the geometry and dimensions of the pipeline. Adequate information on geometrical dimensions was provided.

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[1] Federal Register 41 (No. 233). Thursday, December 2, 1976, pp. 52933-52949.

[2] ibid p. 52939

35. The mathematical models also require information about certain mechanical properties of the girth weld metal and the pipe itself, namely, yield and tensile strengths and fracture toughness. In the present analysis, fracture toughness was estimated through measurements of crack-tip opening displacement (CTOD). Although the statistical sampling to determine mechanical properties was limited, adequate technical information was provided to facilitate reliable theoretical calculations of critical crack size curves.

36. The Dugdale Model was used to calculate the stable through-wall crack size. A model developed at the U.S. National Bureau of Standards was used to calculate the stable part-through crack curves.

37. Decision curves were derived from the theoretically calculated critical crack size curves using agreed upon safety factors.

B. Safety Factors

38. Safety factors are used in the fracture mechanics methodology for pipelines to accommodate uncertainties associated with:

1. Inadequate measurement technology for accurate determination of defect depth and defect length from girth weld radiographs.
2. Calculation of critical crack size curves for theoretical models which only approximate the condition of the buried pipeline.
3. Effects of the pipeline construction practices on stresses applied to pipelines.
4. Limited statistical sample sizes for the determination of mechanical properties and toughness of girth weld metal and pipe metal.
5. Unknown dynamic longitudinal stresses which can occur during long term operation.
6. Unknown static longitudinal tensile stresses or unknown static bending stresses.

The safety factors used in analysis of the present request for waiver appear in Table 5.

39. Multiplying the estimated applied static longitudinal tensile stress by the safety factor of 2.1 in Table 5 leads to 52,000 psi as the worst case applied longitudinal stress. This value coincides with the specified minimum yield stress of the pipe. This factor of 2.1 is slightly more

conservative than the safety factor on pipeline hoop stress, which is implicitly defined for the MPC pipeline as approximately 1.8 in CFR 49, Part 192.

40. The safety factor 1X on measured defect length is consistent with assertions in the December, 1976, Alaska Oil Pipeline Rulemaking that defect length can be reliable measured on girth weld radiographs. Level III radiographers at Southwest Research Institute made similar assertions about the radiographic film from the present Montana pipeline.

41. The safety factor on defect depth varies with the type of defect. It is recognized that defect depth cannot be reliably measured from radiographs. Consequently, all weld defects are assumed to be one weld pass deep at the time of construction. The worst case depth estimates appearing in Table 5 range from three weld passes for crack defects to one weld pass for non-planar defects. This ranking reflects the severity of the stress intensity of the notch acuity at the tip of each type of defect.

42. Besides the safety factors appearing in Table 5, an additional safety factor implicitly appears in the fracture mechanics calculations of critical crack size curves. It appears in a fracture toughness term call "residual stress." This term is intended to account for loss of fracture toughness at a crack tip due to 1) localized plastic strains resulting from thermal contraction stresses which develop during cooling of a weld, and 2) localized plastic strains resulting from bending stresses imposed by construction practices and/or soil shifts.

43. The "residual stress" term used in the present analysis is a displacement of 0.001 inches. It showed up as a reduction in average crack-tip opening displacement (CTOD) at 35 degrees fahrenheit from 0.006 inches to 0.005 inches.

C. Decision Curves

44. Figures 1-4 are the decision curves derived from theoretically calculated critical crack size curves using the safety factors in Table 5.

45. Figure 1 shows the decision curve for cracks. The shaded area along the vertical axis is the envelope of crack sizes for which waiver is requested. Table 6 lists the size and location of all cracks in the envelope. All cracks in this envelope fall below the decision curve. Consequently, all crack sizes contained in this envelope are eligible candidates for a waiver. It is recognized that

individual cracks in a weld with multiple cracks must be at least the longest of the length of any involved crack from one another to be considered eligible.

46. Figure 2 shows the decision curve for planar defects of the incomplete fusion type. The shaded area along the horizontal axis is the envelope of incomplete fusion defect size for which waiver is requested. Table 7 lists the size and location of the defects in the envelope. All defects in this envelope fall below the decision curve. Consequently, all defect sizes contained in this envelope are eligible candidates for a waiver.

47. Figure 3 shows the decision curve for planar defects both inadequate penetration and inadequate penetration due to high-low. The shaded area along the horizontal axis is the envelope of defect sized for which waiver is requested. Table 7 lists the size and location of the defects in the envelope. All defects in this envelope fall below the decision curve. Consequently, all defect sizes contained in this envelope are eligible candidates for a waiver.

48. A probabilistic risk analysis was carried out to evaluate the likelihood that a crack exceeding its critical dimensions on Fitness-For-Service basis exists in those girth welds for which the radiographic record is incomplete or uninterpretable. Results of a preliminary analysis and a subsequent analysis appear in Table 8. These results indicate that the probability of such cracks existing is in the range of 1.1 to 3 percent. (A more conservative analysis based on the shorter critical crack length of one-inch appearing in the decision curve for cracks, Figure 1, would increase the probability.)

49. The predictions of the probabilistic risk analysis appearing in the last column of Table 8 were not verified during hydrostatic tests of the buried pipeline carried out in 1983-1984. Since the hydrostatic testing represents the worst-case loading on the pipeline to date, and since no leaks were detected in the regions of the missing or defective radiographs, it is concluded that the statistically-inferred cracks do not exist and therefore cannot be a serious threat to the reliability and safety of the 104 miles of constructed pipeline.

IV. MONITORING DEFECTS IN SERVICE

51. Consideration of waiver for a large number of pipeline girth weld defects using fracture mechanics as the basis for decision making is not unprecedented. For example, at the time

of the Alaska Oil Pipeline Rulemaking[1], a waiver of federal pipeline regulations for an estimated 7,866 girth weld defects was granted. However, no cracks were included in this waiver. Furthermore, federal regulations pertaining to cracks in pipeline girth welds have not been waived to date for any pipeline.

52. The present request for waiver includes 35 cracks one inch in length or less in 35 different welds. Because of the unprecedented nature of this request for waiver, the PSC finds it necessary to include a requirement for a crack monitoring procedure as a condition to granting a waiver for those cracks which are eligible candidates for a waiver. This proposed requirement is consistent with fracture mechanics methodology used in other engineering applications in which Fitness-For-Service evaluation is based on analysis using current crack size. This monitoring approach facilitates evaluation of time-dependent deterioration.

53. MPC must develop a crack monitoring procedure that includes at least radiographic and ultrasonic techniques to monitor possible growth of at least four cracks during the first five years of pipeline operation. The cracks chosen for monitoring shall be in the area of the pipeline subject to the highest operating pressure. In addition, if any cracks are in other than Class I location, at least one of those cracks shall be monitored. Furthermore, an annual written report of monitoring results must be provided to the PSC and to the office of Pipeline Safety, U.S. Department of Transportation, Washington, D.C. In addition, as well as complying with the reporting requirements of 49 CFR, Part 191, MPC must notify the PSC and the OPS/DOT within 24 hours of a leak which originates at a girth weld.

54. A further condition of granting this request for waiver is that if three girth weld leaks occur during one 12-month period of normal pipeline operation, the pipeline will be removed from service until a complete study of its reliability and safety, particularly with respect to time dependent deterioration, can be carried out. This condition will apply for the useful life of the pipeline.

55. A further monitoring procedure related to granting this request for waiver is that the pipeline's stability in the ground be monitored using a caliper pig to detect dimensional and shape changes indicative of changing pipeline stability. This pipeline stability monitoring is to be carried out at least annually for the first three years of pipeline operation. An annual written report of results

[1] Federal Register 42 (No. 121) Thursday, June 23, 1977, pp. 31859-31861.

is to be provided to the PSC and OPS/DOT. Assessment of results from the first three years by interested parties will prove the basis for a decision about the need for continued stability monitoring.

56. Another monitoring procedure related to granting this request for waiver is that possible damage to the protective coating for corrosion control must be monitored using suitable information from cathodic protection procedures employing impressed voltages, and supplementing this information with techniques for detecting holidays in the coating if necessary.

57. Considering the additional remedial work that must be performed and with a comprehensive monitoring program in place, the Commission accepts Montana Power Company's conclusion that if all girth welds for which a waiver is being requested were brought into literal compliance with the code, this could result in an unnecessary expenditure of time and resources, and even be counterproductive in terms of safety. In addition, the environmental disruption should not be overlooked.

CONCLUSIONS OF LAW

1. The Commission has jurisdiction over the matter addressed in these dockets, pursuant to the Natural Gas Pipeline Safety Act of 1968, 49 U.S.C. 1671 et seq. and 69-3-207, MCA.

2. Since 1968, the Commission has been authorized by the U.S. Department of Transportation to enforce the provisions of Natural Gas Pipeline Safety Act.

3. The Commission is authorized to grant waiver as requested in these proceedings pursuant to Section 1672(d) of the Natural Gas Pipeline Safety Act of 1968, as amended.

4. Based upon a thorough review of the entire record, discussions with the parties and their experts and discussions with its own staff and consultant, the Commission concludes that the waiver requested by the Montana Power Company is appropriate, reasonable, and will not threaten the safety of the people of Montana.

ORDER

1. The request for waiver, as filed on August 6, 1985, is granted, subject to the conditions regarding monitoring and reporting described in this order.

2. The Montana Power Company is ordered to file the reports described in this order's Findings of Fact.

3. The Montana Power Company is ordered to prepare and submit for the Commission's approval a monitoring program which complies with the monitoring needs described in this order.

DONE AND DATED this 27th day of January, 1986, by a vote of 4-1.

BY ORDER OF THE MONTANA PUBLIC SERVICE COMMISSION .

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JOHN B. DRISCOLL, Commissioner

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HOWARD L. ELLIS, Commissioner

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TOM MONAHAN, Commissioner

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DANNY OBERG, Commissioner

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CLYDE JARVIS, Chairman
(Voting to Dissent)

ATTEST:

Trenna Scoffield
Commission Secretary

(SEAL)

NOTE: Any interested party may request the Commission to reconsider this decision. A motion to reconsider must be filed within ten (10) days. See 38.2.4806, ARM.